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ABSTRACT

This study investigated gender differences in preschoolers' problem solving. Ten boys and 10 girls from the same preschool class with a median age of 4 years 1 month from multicultural middle class families participated. Children were presented with a separate novel form board puzzle designed for young children each day for 3 days in a standardized order. Children were later asked to explain how to do a puzzle for a friend in the class. Experimental sessions were recorded on videotape. Children's speech during puzzle completion was recorded and coded for two forms of social and six forms of inner speech. Puzzle-solving performance was coded according to five motor behavior categories. Several gender differences were reported: (1) Girls were more likely than boys to complete all the puzzles; (2) Boys were more likely than girls to use trial and error and had shorter latencies to begin puzzle completion, whereas girls tended to look for clues and related their prior knowledge to the puzzle to develop a strategy; (3) Boys were more likely than girls to use social speech during pauses between motor acts; (4) Speech did not occur as often as in previous studies, and task success was not associated with private speech, especially for girls, the verbalizations actually accrued within a series of failed or nearly failed activities mostly for boys; (5) Girls were more persistent than boys; (6) Girls were better able than boys to verbalize their strategies both to the experimenter and to a classmate. (Includes 1 table and 2 figures. Contains 14 references.) (KDFB)

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PUZZLING BOYS AND GIRLS

(gender differences in problem-solving in preschoolers through puzzles)

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INTRODUCTION

The debate over how to explain human behavior has been going on for years. Currently, many studies are concluding that heredity plays a larger role in development than environment (Plomin, Reiss, Hetherington, Howe, 1994). In spring 1995 researchers at Yale University School of Medicine captured widespread attention when released the results of a study that found the first definitive evidence that men and women use their brains differently (Shaywitz, S., Shaywitz, B., 1995, February 16). This study has added more fuel to the debate over sex differences in the brain . Their data provide clear evidence for sex differences in the functional organization of the brain for language and indicate that these variations exist at the level of phonological processing (rhyme).

According to neuropsychologist Doreen Kimura (1992), biological differences at birth in the male and female brain explain the differences in behavior between boys and girls. Sex hormones affect the brain prenatally and cause it to become organized differently for each gender. Women and men differ not only in physical attributes and reproductive function, but also in the way in which they solve intellectual problems . The bulk of evidence suggest that the effects of sex hormones on brain organization occur so early in life that from the start the environment is acting on differently wired brains in girls and boys. Men perform better then women on spatial tasks. They outperform women in mathematical reasoning tests and navigating their way through rout. Men are more accurate in tests of target-directional motor skills. At the same time, women tend to be better than men at rapidly identifying matching items, a

skill called perceptual speed. They have greater verbal fluency, including the ability to find words that begin with a specific letter or ful ill some other constraint. Women also outperform men in arithmetic calculation and cure faster in certain precision manual tasks, such as placing pegs in designated holes on a board.

The present study was designed to investigate whether are differences in the cognitive ability of preschool boys and girls in their problem solve . The problem solving task was selected to be difficult, but not totally impossible for a preschool child to complete unassisted. In the context of the present study, it also had to be a task difficult enough that it would be likely to elect metacognitive activity (Meichenbaum,Burland, Gruson & Cameron, 1985). Through pilot observation, a set of form board puzzles were selected as a task likely to meet these criteria.

Puzzles greatly appreciated by young children are an excellent resource for developing good problem solving skills. This thinking, manipulating and independent activity, provides the developmental milestones for logical, as well as, abstract thinking. The children are actively observing, recognizing likenesses and differences, familiar images through physical manipulation, using trial attempts to make puzzle pieces fit into the frame and complete an image . Having moved through the analysis of the puzzle, finding strategies to complete and evaluating the results, satisfaction is achieved . Children are working towards cognitive closure as they engage and achieve the completion of a puzzle. This requires attention and concentration on their part. While observing young children working with puzzles you notice that they often talk to themselves or even sigh and hum as they work. They engage in the use of social and private speech. Observing this interesting

phenomenon is one of the way seeing the child's thinking (Vygotsky, 1986) . Puzzle making is a good independent activity which allows us to easily observe children. Their concentration, body movements, language, thinking in the form of problem solving and making choices are accessible to the observer.

METHOD

SUBJECTS

The subjects were 20 children ranging in age 3,5 - 4,5 with a median age of 4,1. There was an equal number of boys and girls. All children were attending Child Development Center in Bronx, New York. Subjects were drown from multicultural middle class families.

EQUIPMENT

The experiment equipment consisted of 4 hardwood puzzles (body parts, hands, shapes, alphabet), designated by the manufacture as appropriate for children of age 2-6 years. Each puzzle had a picture on a solid background and was composed of 10, 12, 18, 26 pieces. The experimental puzzles were not previously available to the children in the

experimental puzzles were not previously available to the children in the classroom (all the children attended the same class).

The experimental sessions were recorded on the videotape by experimenter. The video camera was used to record the frequency, duration and category of the verbal and motoric events. Then the results were scored and putted in a written transcript. Camera was used in order to avoid misclassification in scoring the children's private speech (Sherryl Hope Goodman, 1981).

All children had prior knowledge of general puzzle solving strategies and were also familiar with the puzzles pictures subjects. All puzzles were administrated to all children in a standardized order (Kontos, 1979) .

PROCEDURE

The experimenter invited each child to play with some puzzles in a small room adjoining the preschool. The child was seated at the small table in view of the researcher so that both the child and the puzzle could be viewed by the camera. After the child was seated , the experimenter instructed the child that the puzzle solving would be timed. The child was told to work alone and given the instructions :

"I have a set of puzzles. Try to do the puzzle before the time is up - try to beat the timer! The puzzles are hard enough that you may not get any pieces on , but that's o'kay. The important thing is to try hard for 5 min. I'll tell you when you can stop. I'll

come back every day this week and let you practice on another puzzle (puzzle presented). Here is the puzzle. I'll take the pieces off for you and you can start now. You have 5 min, to work on the puzzle by yourself. You can say whatever you want to, but I won't help you, because it's your own puzzle to work on ."

Children were removed from their classroom daily at the same time for 4 days, for approximately 15 min each time. It was only one puzzle used each time in order of increasing their complexity (from the easiest to the most difficult).

The administration of the problem- solving task began with all puzzle pieces in place on the base so that the child could see the finished state of the puzzle (Kontos, Nicholas, 1984). The pieces were removed from the puzzle base in a standardized fashion so that there was no apparent relationship between the placement of the piece on and off the puzzle. The experiment was started as the child picked up the first piece and the session ended when the 5 min limit was reached. The time limit was imposed to give sufficient time for puzzle solution to the more skilled children while minimizing frustration for those who where unable to solve the puzzle (a similar procedure was used in Kontos (1983)) .

During each session four measures of two types of problem-solving skills were made. Problem-solving success was measured by the number of pieces (N) correctly placed and the number of seconds to the first

piece placement (T). Metacognitive skill, strategic knowledge/awareness, was measured by observing children using different strategies (sorting by colors, shapes, pictures, boarding and so on...).

Each child was also asked, "What did you do (or try to do) to get those pieces on the the puzzle ?" Consistent with recommendations of Meichenbaum (1985), the questions were asked immediately following completion of the puzzle and probes were limited. Responses to the strategy questions were recorded and corded for presence or absence of a verbalized strategy guiding puzzle completion and for the number of strategies mentioned (stop what is not working, try both sides of a piece, rotate each piece , remember the original location of the piece on the board and etc...).

Additional format for eliciting strategic knowledge was included for Day 5 to provide converging evidence (Cavanaugh , 1982). It was also a verbal measure, but different from the first, because of its presumed greater ecological validity and meaningfulness to the children (Kontos, 1989). The children were asked to explain how to do the puzzle for a friend. Their explanations were taped and recorded for payback. Responses were corded and compared with the previous data.

Level of cognition was measured by recording children speech (social, private, inner...). While, according to Sherry Hope Goodman (1981), success on the task is associated with and occurs in the presence of private speech, the verbalizations actually occur within a series of failed or nearly failed acts in the sequence of puzzle-solving activities. Findings were interpreted in the light of Vygotsky's notion of the integral use of language in children's task performance.

The children's speech was categorized into 2 forms of social speech (task relevant and task irrelevant) and six forms of private speech (word play, description of activity, questions asked and answered by self, comments to absent and nonhuman others, verbalizations of plans or thoughts and emotional expletives.

Puzzle-solving performance was unitized into puzzle solving acts. An act was defined as a behavior beginning when a child picked up a piece to be placed in the puzzle and ending when that piece was either placed in the puzzle or returned to the table. Each acts was then categorized according to a five points scheme, developed by Goodman, (1981).

The five motoric categories were as follows:

1. Immediately successful placement : the piece is placed correctly with little or no hesitation.
2. Success following spatial reorientation: the piece is correctly placed in the correct spot but requires adjustment of position before it is correctly placed.
3. Success following trial and error: the piece is correctly placed after one or more unsuccessful attempts.
4. Failure, due to placement error: piece placed in incorrect spot.
5. Failure : piece returned to the table , following unsuccessful attempt to place piece, child returned piece to the table.

Time when child paused was corded as "no motor behavior"

Table 1.. Speech Categories : Definitions and Examples

Category	Definition	Example
Social speech: Task-relevant social speech	Eye contact with experimenter and/or demand for response; content relevant to task	"You put this one." "All finished! "
Task-irrelevant social speech	Eye contact with experimenter and/or demand for response; content not relevant to task	"We have dog at home."
Private speech: Verbalizations of plans or thoughts	Content relevant to task; analysis of situation; state reasons for action or interaction	" I don't know where this goes" "Try another one here."
Questions and answers to self	Planning or self-guiding	"Where does this go?"
Description of activity	Content relevant to puzzle or labeling visually obvious aspects of the activity	" That's a boy ." " There, I got one."
Word play	Singing and humming; repeating words and phrases	" A, B, C, D..."
Comments to absent/nonhuman others	Content suggests spoken "as if" to another or object	" Look, I did it!"
Emotional expletives	Expression of feelings about task success or failure, or frustration; positive or negative evaluation	"Ta da!" "I ca-a-n't"

PS.: There were few changes in a procedure during the experiment period:

1. As there was no evidence of a deadline effect on increasing children's interest in problem-solving (some children simply couldn't concentrated

on activity, when a deadline was mentioned), the deadline was not mentioned any more. The children were asked to"beat the clock" if they could , but it was not their goal, the main thing was to "try hard"(contradiction of Dollinger and Reader).

2. It turned out, while conducting the experiment, that 5 min. limit time was not enough to complete these particular puzzles for some children. So the time limit was changed from 5 to 10 min, in order to avoid frustration and give children chance to complete puzzles. But in some cases children were insisting on continuing puzzle-solving activity even after 10 min period and managed to complete puzzle on their own. On the other hand,when the child was bored and lost interest after trying for 5 min, or there were some evidence of frustration, the experiment was stopped right away and the child was awarded with a sticker for "trying hard". So the time limit was various. Because of that , we had to change one of the measures of a puzzle-making success: instead of "number of peaces correctly placed" we used "the time of completion of the puzzle".

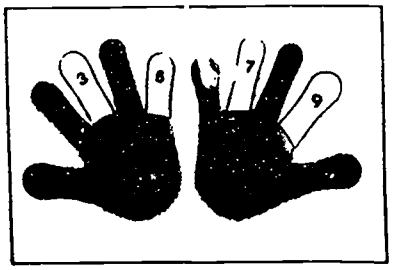
3. It was found that when the children were not in their usual environment (classroom), some of them "froze" and could not perform as well as usually, so instead of using a special room, the experiment was conducted in the a separate quite area in the classroom, with other children playing in the same room.

4. Some children were absent for a long time (vacation, sickness,

holidays) and it was a big period of time between puzzle-solving activities.

5. Only 3 puzzles were used (A, B, and C), because of the lack of the time.

6. The easiest puzzle were supposed to be presented first and then the complicity of the puzzles had to increased. But the puzzle A, which had to be the easiest one and was presented first, appeared to be the most complicated one for boys and girls.



Counting Hands
Ages 3+ Years
Left and right hands with numbered fingers and corresponding number of dots.
Measures 8¾" x 11¼"
105-01051

Deluxe Alphabet Puzzle
Wooden puzzle with lift-out letters and printed letters and corresponding objects beneath.
Size: 11⅝" x 15⅝"
104-81051

RESULTS

The were significant differences in the way boys and girls were solving puzzles and used their metacognitive skills:

1.All girls completed their puzzles. (No=0, no failures among girls) However 3 boys failed , one of each different puzzles. (No= 3)

2.Boys and girls used different strategies. Majority of boys (N=9, 90%), even those , who quickly an successfully completed their puzzles , used "trial and error" strategy as their main one , or, by another word , had no strategy at all. They simply were picking the closest piece from the table and placing it "somewhere" on the puzzle board, trying to find a correct spot for it. All boys , as well as girls, were aware of different kinds of puzzle-solving techniques (rotate the piece, try one piece in different sports, try different pieces in the same spot and ... so on), but boys used them only as support, not as a strategy. Boys time to the first piece placed on the board was T=0.

While all the girls were looking for clues first, developing main strategy, and only , when they had made a decision about what kind of strategy they were going to use, girls placed the first piece, usually correctly. Time to place the first piece on the board T= 4-6 sec.

3. While looking for cues , all girls used their priorknowledge and other skills in order to solve the problem. While boys looked at it as a wooden board with pieces that needed to be placed correctly, the girls could identify the puzzle as letters which had to be placed in the alphabet

order , or numbers from one to ten, or body parts . Combination of problem-solving techniques and prioknowledge helped girls to outperform boys in this particular experiment. Having a main strategy , the girls didn't have to use a lot of puzzle-solving techniques, like the boys, who had to try everything they could in order to succeed or fail.

4. While working with puzzles, the girls were very concentrated and independent. They did not use social speech in order to get help from the experimentator . The boys were quite the opposite, they constantly were looking for support or help. Even if their performances were successful , they needed some kind of approval that "it was all right".

5. When girls were having difficulties, they were trying harder and harder to solve the problem on their own, and if they failed , they just were making a statement; "I can't do it, it is too hard...".

While boys were constantly referring to the experimenter asking for help. So , as you can see , girls used almost no social speech in order to get help(N = 1, 10 %), while boys were using it a lot (n=7, 70%).

6. Children were not using speech a lot,in comparison with the Goodman study , or the Kontos findings, or the Vygotsky theory. Success on the task was not associated with and occurred in the presence of private speech, especially for girls, only 20% of whom used private speech at all. The verbalizations actually accured within a series of failed or nearly failed acts in the sequence of puzzle-solving activities mostly for boys .

7. Girls were , in general, more persistent and patient in this particular experiment, even if they experienced some difficulties, while performing the task. Some of them were completing their puzzles in 14 min. period, but on their own, without any assistance at all.

While boys were "giving up" easily, if they were no given any support or approval from the adult. Some of them were bored in a period of time less then 5 minutes. Boys also were easily distracted by other activities in the classroom, while girls seemed didn't care about anything else, but the task they were working at.

8. All girls (N=10, 100%) were able to verbalize their strategies after completing the task and did it correctly , step by step following their motoric activities. The boys (N=6, 60%) were unable to verbalize it at all. Other 4 boys (40%) were able to describe what they were doing, but very poorly, without any connections with their real motoric events in solving particular puzzle ("put this here or there,...or this..then that.. and you are done..")

None of the boys could explain verbally to their friends the way to complete any of the puzzles , even they could solve it easily by themselves . They only could show how to do it , but not tell. While girls could do it easily (N=8, 80%), exactly following their own steps in solving the puzzle, plus they could explain why did they used this particular strategy or technique.

Figure 1

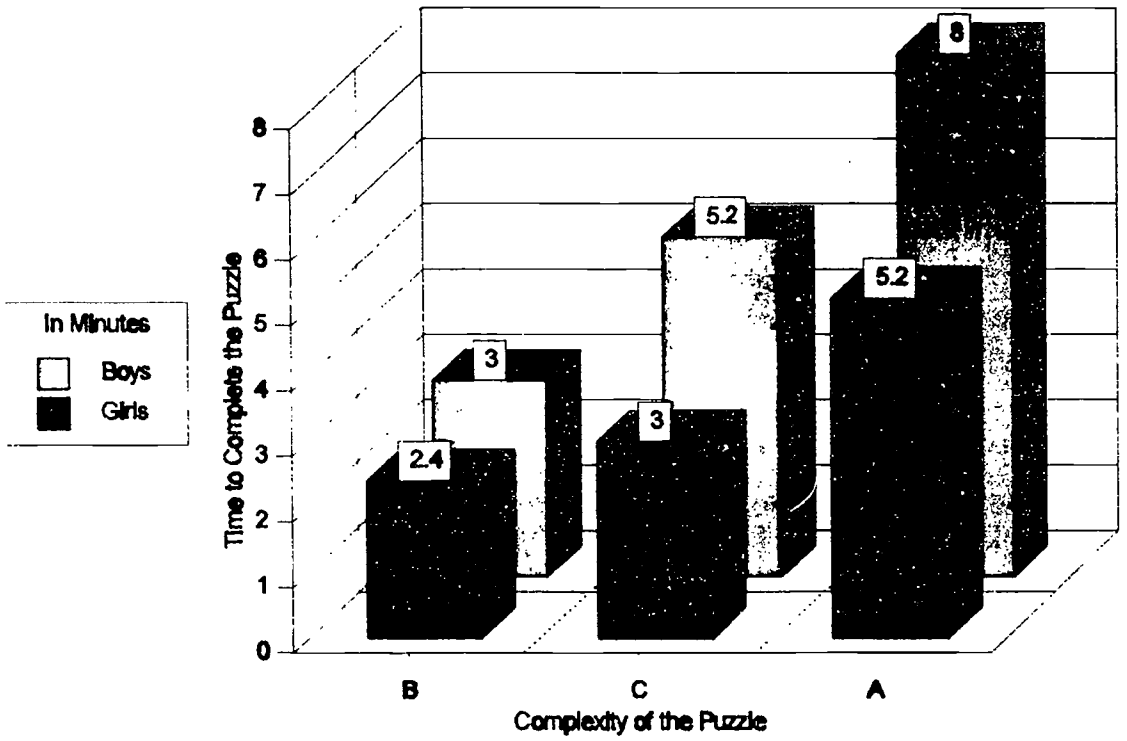
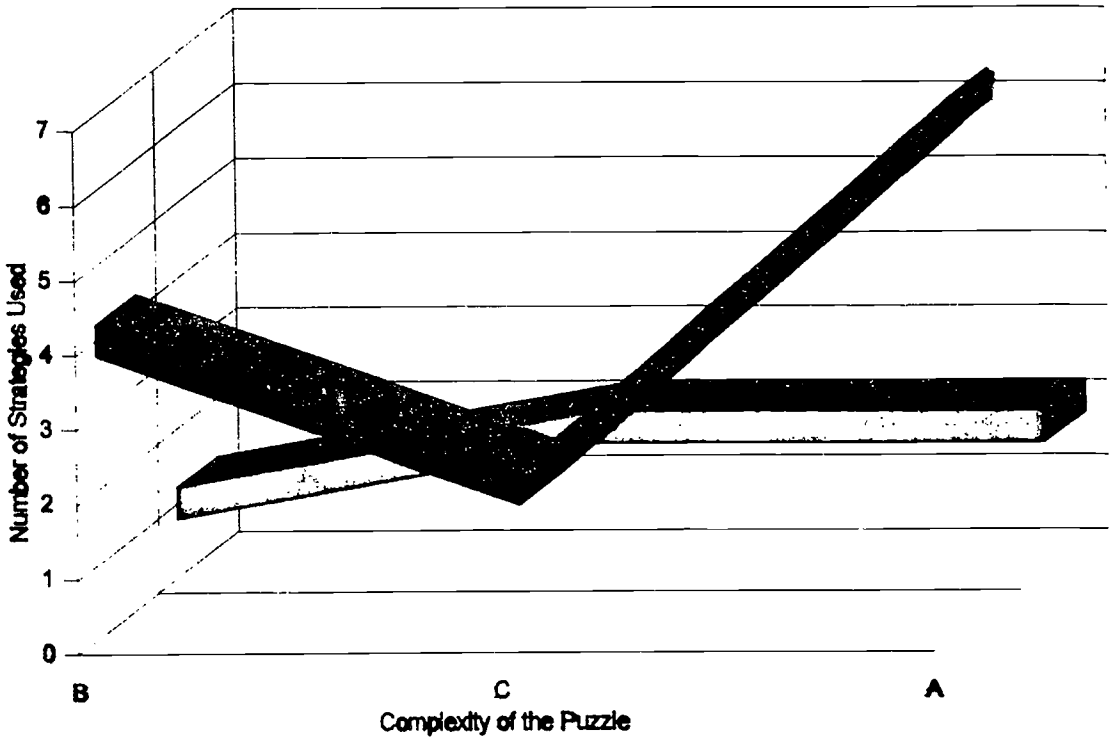


Figure 2


7
6
5
4
3
2
1
0
Number of Strategies Used
B
C
A
Complexity of the Puzzle

ANALYSIS

Description of Verbal and Motoric Events.

1. The first step in the analysis was to examine characteristics of children's private speech, its rate, distribution, and relationship with puzzle-solving behavior. Boys and girls were found to differ significant in number or rate of verbalizations , motor acts and puzzle-completion time.

To complete the tree puzzles, the mean observation time for girls was 10 min ,3 sec, ranging from 6min, 6 sec to 21 min, 4 sec. While, the mean observation time for boys was 17 min, 35 sec, ranging from 7 min, 2 sec to 31 min, 5 sec . Girls outperform boys in completing the puzzles.

2. During puzzle-solving activities the 10 boys emitted a total of 345 speech units over the course of the three puzzles, only one boy use no verbalization at all . In contrast, 10 girls emitted only 210 speech units over the course of three puzzles, with 4 girls using no verbalizations during the entire task. Boys were more talkative than girls , some of them had 20 verbalizations per minute.

3. At the same time, all ten girls could verbalize their strategies after completing the task, while only 4 boys could describe their performances and very poorly (six boys couldn't explain anything at all).

4. For the group of girls as a whole (N=10), 81% (170 units) of the verbalizations were categorized as private speech. While, for the group of boys as a whole (N=10), 75% (259 units) of the verbalizations were

categorized as task- relevant social speech As we see, girls used mostly private speech (verbalizations of plans or thoughts, description and questions to self), while boys were referring their speech to the experimenter, asking for help or approval.

5.It was noticed that, puzzles on which girls emitted a high rate of puzzle-solving moves, also tended to be accompanied by a lower rate of verbalizations, but were solved in a shorter time. In other words, the faster the rate of motoric acts, the lower rate of the speech.

As for the boys, the faster the rate of motoric acts and shorter the time they took to solve the puzzles , the greater the rate of emotional expletives they had.

6. But , in general, the girls were more efficient than boys. They solved puzzles faster and used more private speech, rather than social. The rate of their private speech increased with increasing the complexity of the task. The boys used more social speech, when experienced difficulties during performance of their task.

7. The motoric behavior itself was examined next. Since most of the girls tended to pause for at least 1 sec between acts, the most frequently occurring behavior for the girls was the designated as "non motoric behavior" (45 %), while for the boys, the most frequently occurring behavior was failures due to incorrect placement, occupying 49% of the observation time.

Proportional Distribution of motor Acts of puzzle- solving Behavior

puzzle-solving behavior	girls %	boys %
Non motoric activity	45	5
Immediately successful placement	31	15
Success with reorientation	10	10
Success with trial and error	5	10
Failure-incorrect placement	4	49
Failure-returned to table	5	11
Total number of puzzle-solving acts	1,523	2,894

Puzzle-solving Success and Failure

Next examined was the experimental manipulation for failure of the children's efforts to complete the puzzles. Contrary to Goodman's findings, children's puzzle performance following failed puzzles was accompanied by more speech than on those puzzles following successful puzzle completions. Girls used more private speech, while boys were asking more questions, experiencing failure.

Co-occuring Speech and Puzzle-solving Behaviors

By examining the indications of behavioral occurrences on the event recordings, it was possible to determine where in the sequence of motor

events, each verbalization occurred. In other words, what is the distribution of 210 speech units and 1523 motoric puzzle-solving units for girls, as well as 345 verbal speech units and 2,894 motoric units for boys.

On initial examination of the data, it was found that 85 % of all verbalizations (speech categories combined) for girls occurred during motor acts (mostly in a failure situations), while for boys 73% of all verbalizations accompanied the pauses between behavioral acts, when they used task-relevant social speech ,followed by failures with placement errors.

Discussion

The results of the present study are consistent with those reported by Goodman, that puzzle solving proved to be an appropriate task in that it is inherently interesting to young children. It permitted a description of the child's moment-to-moment problem-solving activity, and children spontaneously verbalized when during the task. Children's speech was observed to be used differently by girls and boys , while performing the same task. In the present study, the induced task failure did result in larger amounts of speech forms, contrary to the findings of Goodman. The results suggest that the child, when experiencing difficulty on the

task, verbalized more in attempt to overcome the difficulty, which is consistent with the suggestions of Vygotsky and Luria that speech would increase as the task become more difficult. Thus, the present data clearly indicate that boys and girls use their speech differently: girls intend to use private speech as cognitive self-guiding behavior, while boys prefer to use social speech in order to get some help or support from adults. To explain these results it is sensible to conclude that girls have a higher individual level of cognitive functioning (self-directed learners) , than boys, who need more adult's assistance and guidance (other-directed learners). This findings are consistent with the results reported by Shaywitz recently that there is a sex difference in the functional organization of the brain for language. Boys and girls use their speech differently.

The results of the present study also indicate that girls use a higher amount of metacognitive content in a problem solving setting: knowledge(recall or recognize information, ideas and principals in the approximate form in which they were learned), comprehension(interpret information based on prior learning), application(select, transfer and use data to complete the task with a minimum of directions), analysis (aware of thought process in use and can examine and draw conclusions to the nature of a task), synthesis(integrate and combine ideas into a product, plan). Even though, use of some categories of metacognitive content was similar for boys and girls (knowledge and analysis), girls used a

higher level strategy variables and analytic attitude. Girls were more likely than boys to vary the use of several categories of metacognitive content in order to accomplish the task.

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